Bibliometric review of the research overview on green concrets

Revisión bibliométrica del panorama investigativo en concretos verdes

Valentina Escobar Dávila[1]
Carlos Andrés Rubio Castaño[2]
Daniel Aristizábal Torres[3]
Alejandro Alzate Buitrago[4]

Abstract

The manufacture and use of concrete are significant environmental pollutants due to its high CO2 emissions. Contrary to the current postulates of sustainable development and global pacts for the reduction of greenhouse gases, which

1 Student, Civil Engineering Program, Universidad Libre Seccional Pereira
2 Student, Civil Engineering Program, Universidad Libre Seccional Pereira
3 Research Center, Universidad Libre Seccional Pereira, daniel.aristizabalt@unilibre.edu.co
4 Researcher, Universidad Libre Seccional Pereira, alejandro.alzateb@unilibre.edu.co

is why during the last 20 Years have been developing new techniques and use of alternative materials, as raw material for the manufacture of concrete, with satisfactory results in terms of durability and resistance. The search was advanced in the Scopus database, using the search equation "green concretes", filtering by title. Using bibliometric and network visualization tools, such as RStudio and VOSviewer, the information corresponding to 201 documents was processed and evaluated. The most significant findings indicate that China and India are leading the research on new technologies to use recyclable raw materials in the manufacture of green concrete, causing the global environmental impact in the construction sector to decrease. Additionally, it was found that the most relevant sources are the *Journal of cleaner production* with 20 published articles corresponding to 9.9% and *Construction and building materials* with 15 articles, of the total distribution of publications.

Keywords: bibliometric indicators, CO2 emissions, collaboration networks, concrete industry, scientific mapping, environmental protection.

Resumen

La fabricación y uso del concreto es uno de los mayores contaminantes ambientales debido a sus altas emisiones de CO_2, en contravía de los actuales postulados del desarrollo sostenible y pactos globales por la disminución de los gases efecto invernadero, razón por la cual durante los últimos 20 años se han venido desarrollando nuevas técnicas y aprovechamiento de materiales alternativos, como materia prima para la fabricación de concretos, con resultados satisfactorios en cuanto a la durabilidad y resistencia. Se adelantó la búsqueda en la base de datos Scopus, mediante la ecuación de búsqueda "green concretes", filtrando por título. Mediante el uso de herramientas bibliométricas y de visualización de redes, como RStudio y VOSviewer, se procesó y evaluó la información correspondiente a 201 documentos.

Los hallazgos más significativos indican que China e India lideran las investigaciones de nuevas tecnologías para el uso de materias primas reciclables en la fabricación de concretos verdes, propiciando que el impacto ambiental a nivel mundial en el sector de la construcción disminuya. Adicionalmente, se encontró que las fuentes más relevantes son el *Journal of cleaner production* con 20 artículos publicados correspondiendo al 9.9% y *Construction and building materials* con 15 artículos, de la distribución total de publicaciones.

Palabras claves: emisiones de CO_2, indicadores bibliométricos, industria del hormigón, mapeo científico, protección del medio ambiente, redes de colaboración.

Introduction

In recent decades, the emission of carbon dioxide (CO2) through human and natural processes and human activities in eliminating waste materials and natural resources consumption (Sanyal, Kodgire, Desai, Saxena, Singh, & Dasgupta, 2020; Shukla, Gupta, Goel, & Kumar, 2020) is considered the most important cause of climate change. In the construction industry, cement production (Nguyen, Chang, Lee, & Shih, 2020) is one of the main contributors to the increase in CO2 emissions in the world (Azarsa & Gupta, 2020[a]; Azarsa & Gupta, 2020b). Khalil & Al Obeidy (2020); Saadoon (2019); Turuallo & Mallisa (2019) concluded that concrete is an essential material for the construction of many infrastructures (residential, bridges, roads) and civilizations around the world. Also, every year concrete production exceeds 120,000 million tons. Among those are cement with approximately 1,600 million tons, 1,000 million tons of aggregates, and 1,000 million tons of water.

Authors Zhao, Gao, and Yang (2020) explained that the production of a quantity of cement generates almost the same quantity of CO2 gas that causes ecological damage, indicating

that the manufacture of concrete has a considerable influence the environment and health (Haza, Shulhan, & Kadis, 2020). Likewise, Hamada et al. (2020) investigated that cement consumption in 2010 was 3.27 billion metric tons and is expected to rise to 4.83 billion metric tons in 2030, possibly causing climate change. The conservation and protection of the environment had become a problem of global context, for which since the world summit of the earth in 1997 in Kyoto Japan the need to reduce CO2 emissions on a large scale was created (objective before 2010 was to reduce by approximately 21%) to avoid a global catastrophe, large industries and countries around the world agreed to formulate a regulation that dreams of emissions of protection and preservation of the environment (Suhendro, 2014)

O'Reilly et al. (2010) indicate that the optimal management of concrete technologies must be considered concerning the built works' useful life. In addition to the conventional aspects that have marked their management until today, it is necessary to consider the aspects of the environment and the ecological impacts that occur. From the same premise Saadoon (2019), Suhendro (2014), Palanisamy (2020), Al-Mansour (2019) ensure that the raw materials of concrete are mining at very high temperatures 1,500 C. Also, Oyebisi (2020) mentions that concrete releases a tremendous amount of carbon dioxide CO2. The reported rate in global emissions in 2004 was 7%. Katiyar & Pal-Singh (2019) and Azarsa & Gupta (2020b) stated that large amounts of different types of plastic and glass waste are created worldwide. These wastes are buried in landfills because plastic and glass do not degrade quickly. This method seriously damages the environment. The researcher Al-Mansour et al. (2019) describes the importance of human beings finding new solutions to preserve the environment. The alternatives are to reuse, recycle, and reduce this waste (plastic and glass). The glass is a transparent material made by mixing SiO, CaCO3 at high temperatures and it is a material that takes thousands of years to degrade. Tang (2020), Nursyamsi et al. (2019) describe that plastic is a polymer formed by organic nature

chains. It can be classified into three categories, thermoplastic, elastomer, and thermoset. Worldwide, plastic material increased from 204 million tons in 2002 to 299 million tons in 2013.

Parihar & Pastariya (2020), Zhao et al. (2020) highlight that the production of cement as a construction material is not sustainable since it consumes large amounts of natural materials, 1.5 tons of raw materials are needed to produce each ton of cement, which is the main material in the production of concrete, in the same way, the author Tang (2020) writes that the manufacture of cement is producing the emission of CO2 that leads to global warming and climate change. In parallel, Oyebisi et al. (2020) provides a solution for manufacturing and proposes to develop cementitious materials, a product of industrial waste (Muhamad, Zainol, Yahya, Noor, Hashim, & Shahrazi, 2020), and thus consume less energy in production and reduce the content of cement to be used in the production of concrete. Besides, the use of these materials can give additional benefits and improve specific properties such as strength, workability, and durability of concrete (Turuallo & Mallisa 2019, Nagarkar 2017).

Palanisamy (2020), Tang (2020) describes the concept of green concrete as a drift of saving various natural resources without compromising the needs of the future generation, durability, low cost, recycling, and reuse of waste materials (Thiruvenkitam, Pandian, Santra, & Subramanian, 2020) without losing space, time, and money at your disposal. The engineer Saadoon (2019) clarifies that green concrete is made from 90% recycled materials, so the cost of doing this will be less than cement when it is manufactured in bulk. It also has a production process that does not lead to the destruction of the environment, has high performance and life cycle sustainability. Green concrete technology becomes a historical revolution in the concrete industry. The first green concrete manufactured was made by Dr. WG. in Denmark in 1998 (Saadoon 2019). Al-Mansour (2019) and Nuralinah (2019) ensure that green concrete incorporates

materials that have been used before in industries. However, the development of green concrete does not stop at the utilization of by-products but instead advances through more advanced approaches to investigate material systems to achieve sustainability.

Ali Zidan and Al-Eliwi (2020) state that sustainable construction can be achieved; green concrete technology can be adopted (Bosro, Samad, Mohamad, Goh, & Tambichik, 2020; Bunnori, Alani, Noaman, Johari, & Majid, 2020; Azad, Saeedian, Mousavi, Karami, Farzin, & Singh, 2020). This technology provides savings in natural materials, pollution, and time using waste materials. Today, fly ash is used throughout the world for the construction of buildings. It is a significant by-product of coal combustion. Oyebisi et al. (2020) say that fly ash is mainly used to replace cement, decrease environmental pollution, improve durability, and decrease shrinkage and hydration.

Zhao et al. (2020), Maryoto & Heri Sudibyo (2019) said that the number of researchers interested in new, environmentally friendly building materials increases (Mohammadhosseini, Alyousef, Lim, Tahir, Alabduljabbar, Mohamed, & Samadi, 2020). Traditional Portland cement- based concrete is expected to be replaced by geopolymer concrete due to reducing carbon dioxide emissions. Shanmugavel et al. (2020) say that the Ordinary Portland Cement product releases a focus six times greater than that of CO2 compared to geopolymer-based concrete. Cornelis et al.(2019) believe that a lot of construction waste is generated every second worldwide, which is not used effectively. Many of them are willing to make new land; at the same time, they also cause pollution of construction waste.

This descriptive article aims to provide an overview of the main characteristics of publications in green concretes based on bibliometric analysis. The information presented in this document provides a clear picture of the research progress achieved in research in green concretes (Sadowski, Nikoo, Shariq, Joker, & Czarnecki,

2019; Rehman, Rashid, Zafar, Alqahtani, & Khan, 2020) and can help researchers and practitioners identify the fundamental influences of authors, journals, countries, institutions, references, and research topics.

Materials and methods

For the bibliometric analysis development, the search equation "green concrete" was used by title in the Scopus database, allowing to develop of broad searches and the filters that the researcher defines (Burnham, 2006; Boyle, & Sherman, 2006). The results were filtered by type of document, including only research articles, conference papers, and review articles, and they were considered every year. The search yielded a total of 201 articles, from which the scientometric and bibliometric analysis was developed, using the open-source tool bibliometrix, through the import of bibliographic data from Scopus (Aria & Cuccurullo, 2017). For the bibliometric network analysis and the visualization of scientific information structures, the VOSviewer software (Van Eck & Waltman, 2010), developed at Leiden University, was used. Such action included co-authorship between countries and authors, analysis of co-citation between sources, and the co-occurrence of keywords.

Results and discussion

According to Table 1, of the 201 documents obtained, 54.23% correspond to articles, 39.30% correspond to conference documents, and 6.47% correspond to review articles. It is essential to highlight that, of the articles evaluated, 1,353 keywords are reported, and 573 authors presented them. The primary sources are journals and books with a participation of 56.71%, and 43.29% come from other sources. Just as the average years of publication correspond to 5.53 and the average citations per document are 15.33, which indicates that the average

annual citations per document are 2.496. In addition to the 201 documents, 54.23% are from articles, 39.30% correspond to conference documents, and 6.47% correspond to review.

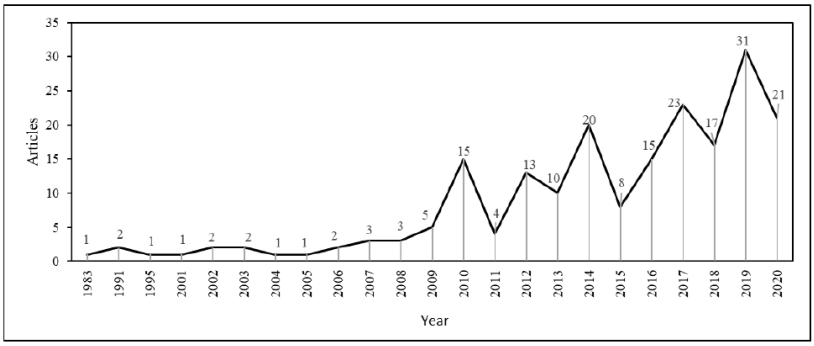
Table 1. *Main information*

Description	Results
Documents	201
Sources (Journals, Books, etc.)	114
Keywords Plus (ID)	1353
Period	1983 - 2020
Authors	573
Document types	
Article	109 (54,23%)
Conference Paper	79 (39,3%)
Review	13 (6,47%)

Annual Scientific Production

The evolution over time and trends of the annual scientific production, in terms of thematic scientific publications, are summarized in Figure 1. Where the first publication on the subject was registered in 1983, and during the following 22 years, the publications were intermittent, showing that publications were, on average, 0.5% per year. From 2006 to 2020, research on green concrete generated its development in the 2000s due to the increase in concrete consumption, which generated environmental impacts that led to the need to use renewable raw materials to manufacture concrete. In the last 37 years, 201 articles were published, and in 2019 it had its greatest boom with 31 articles, corresponding to 15.42% of all publications.

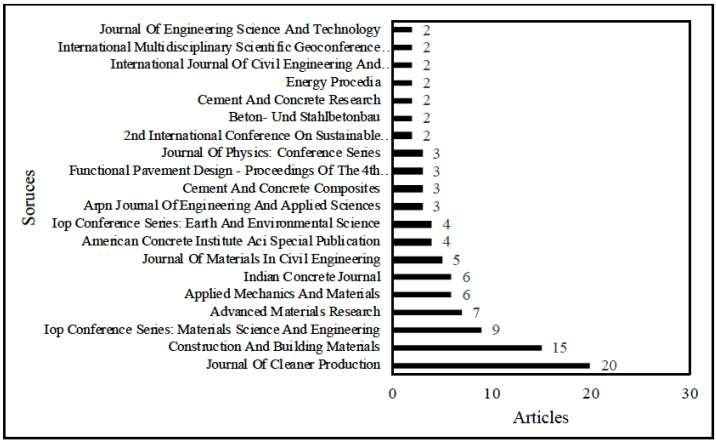
Figure 1. Annual scientific production



Top 20 most productive journals

Taking a total of 201 articles as a reference, Figure 2 shows the top 20 of the most relevant journals. The *Journal of Cleaner Production* has historically been the affiliation with the highest scientific productivity in this field, with a production of 20 articles. Then there is *Construction and Building Materials* with 15 articles and *IOP Conference Series: Materials Science and Engineering* with nine articles. It is evidenced that 95.52% of the journals have only published up to a maximum of 3 articles on green concretes.

Figure 2 *Top 20 most productive journals*



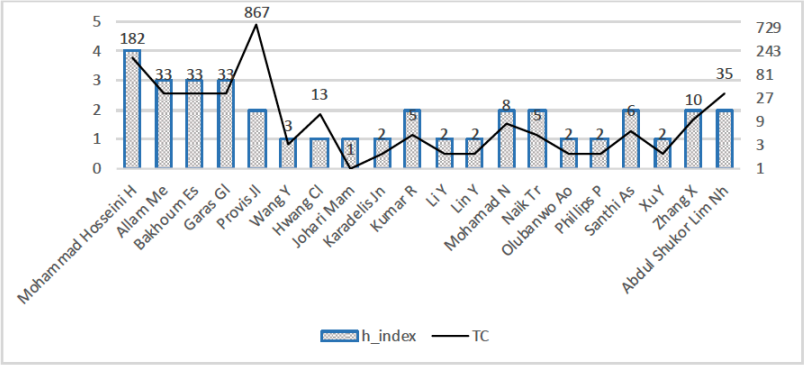
Author's productivity in terms of h-index, g-index, m-index, Total Citations (TC), and Total Publications (TP)

Of the 201 published documents, they were prepared by 573 authors, of which 86.56% are multiple authorship, and 13.43% are a single author. The following indicators can be obtained from the results presented in Table 2, and Figure 3: 0.35 corresponds to the number of documents per author; 2.87 is the value of the number of authors per document, and 3.13 represents the index of collaboration between authors. Additionally, it is evidenced that the five most relevant authors are the professor of the department of mechanical engineering of the University of Hormozgan, Mohammad Hosseini H, with five articles of which 4 have no co-authorship and correspond to 1.99% of the total articles published. Allam Me, an associate professor at the Egyptian National Research Center of the civil engineering department with four articles of which three are not co- authored, corresponding to 1.49% of the total published articles. Bakhoum is a civil research engineer at the University of Nile and Egypt with four articles, of which three are not co-authored.

Table 2. *Authors' productivity in terms of h-index, g-index, m-index, Total Citations (TC) and Total Publications (TP)*

Author	h_index	g_index	m_index	TC	NP
Mohammad Hosseini H	4	5	0.8	182	5
Allam Me	3	4	0.429	33	4
Bakhoum Es	3	4	0.429	33	4
Garas Gl	3	4	0.429	33	4
Provis Jl	2	4	0.143	867	4
Wang Y	1	1	1	3	2
Hwang Cl	1	3	0.1	13	3
Johari Mam	1	1	0.5	1	3
Karadelis Jn	1	1	0.2	2	3
Kumar R	2	2	0.286	5	3
Li Y	1	1	0.091	2	3
Lin Y	1	1	0.2	2	3
Mohamad N	2	2	0.667	8	3
Naik Tr	2	2	0.286	5	3
Olubanwo Ao	1	1	0.2	2	3
Phillips P	1	1	0.2	2	3
Santhi As	2	2	0.25	6	3
Xu Y	1	1	0.2	2	3
Zhang X	2	3	0.182	10	3
Abdul Shukor Lim Nh	2	2	0.667	35	2

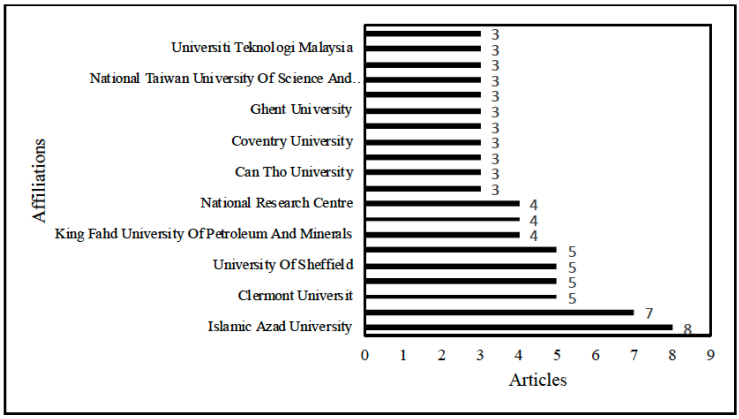
Figure 3. *Relation h-index vs Tc results of the 20 most relevant authors*



Most relevant affiliations

A total of 358 data on affiliations can be seen in Figure 4, the top 20 of the most relevant affiliations by the number of documents. The Islamic Azad University is the sixth-largest university in the world. It was founded in 1982 and had a faculty of engineering | civil society where modern laboratories and workshops have historically been affiliated with the highest scientific productivity in this field, with eight articles. In second place is the University Sains Malaysia. It is the second public university in Malaysia and was founded in 1969. It is one of the oldest universities in northern Malaysia and has 12 schools applied to technology where engineering is found civil. It is a university with many technological advances and resources for which it has seven articles. In third place on the subject is the "Clermont University" is a private university located in California, founded in 1925 and private, specializing in graduate research. They have five articles. The analysis indicates that of the top 20, there are only two North American universities, which indicates that the Asian continent is the one that investigates the issue of green concrete the most.

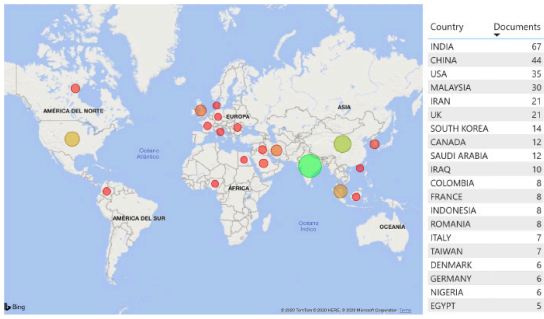
Figure 4. *Most relevant affiliations*



Top 20 countries with the most publications

Figure 5 shows the twenty countries with the highest number of publications. India and China lead according to the number of documents closely followed by the United States. The presence of countries like Iran and Malaysia that double the production of world powers stands out. The presence of Colombia as the only Latin American country and Nigeria and Egypt as African representatives is highlighted. Also, European countries' low participation is notorious, specifically the low presence of Scandinavian countries, only Denmark, whose policies are aimed at sustainable development.

Figure 5. *Most relevant countries*



Country	Documents
INDIA	67
CHINA	44
USA	35
MALAYSIA	30
IRAN	21
UK	21
SOUTH KOREA	14
CANADA	12
SAUDI ARABIA	12
IRAQ	10
COLOMBIA	8
FRANCE	8
INDONESIA	8
ROMANIA	8
ITALY	7
TAIWAN	7
DENMARK	6
GERMANY	6
NIGERIA	6
EGYPT	5

The ten most cited publications

Table 3 shows the ten most cited documents worldwide, with their respective author and total citations. In the first place, we find the most cited the article entitled "The role of inorganic polymer technology in the development of green concrete" by Duxson, published in Cement and Concrete Research, in 2007, with 841 citations and a count per year of approximately 60 citations. In the second position is the article entitled "Environmental impact and life cycle assessment (lCA) of traditional and green concretes: literature review and theoretical calculations" by the author Van Den Heede, published in Cement and Concrete Composites, in 2012, with 256 citations and a count per year of approximately 29 citations.

Table 3. *Top 10 most cited publications*

Document	Author	Journal	Year	Global citation
The role of inorganic polymer technology in the development of 'green concrete	Duxson Peter	Cement and concrete research	2007	841
Environmental impact and life cycle assessment (lca) of traditional and 'green' concretes: literature review and theoretical calculations	Van Den Heede Philip	Cement and concrete composites	2012	256
Engineering and transport properties of high-strength green concrete containing high volume of ultrafine palm oil fuel ash	Megat Johari	Construction and building materials	2012	145
Design of green concrete made of plant-derived aggregates and a pumice-lime binder	Nozahic Vicent	Cement and concrete composites	2012	82
Environmental evaluation of green concretes versus conventional concrete by means of lca	Turk Janez	Waste management	2015	79
A life-cycle approach to environmental, mechanical, and durability properties of "green" concrete mixes with rice husk ash	Gursel Aysegul Petek	Journal of cleaner production	2016	76
Toward green concrete for better sustainable environment	Suhendro Bambang	Procedia engineering	2014	68
Green concrete partially comprised of farming waste residues: a review	Kim Hung Mo	Journal of cleaner production	2016	67
Green concrete production incorporating waste carpet fiber and palm oil fuel ash	Abdul Awal	Journal of cleaner production	2016	67
Properties of green concrete containing quarry rock dust and marble sludge powder as fine aggregate	Shahul Hameed	Journal of enfineering and applied sciences	2009	64

Keywords

In Figure 4, a cloud of the most used keywords is presented. It is important to note that "Concretes" presents the highest frequency (95). According to the figure, the font size and the centrality of each word displayed indicate each topic's relevance. Besides allows visualize, as a whole, the evolution and relevance of each of the topics addressed throughout the publications. The terms "Concretes," "Green Concrete," "Fly Ash" represent 22% of the use of all keywords used by authors.

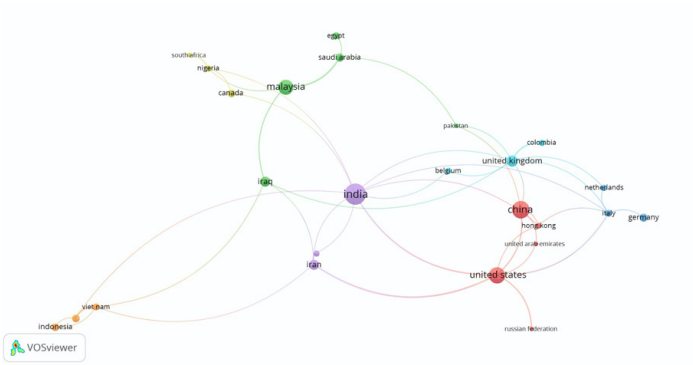
Figure 6. *Cloud of keywords*

Structural Analysis and Visualization in research publications

Co-authorship (countries) in publications

As a result of the search equation, the countries with the highest growth in co-authorship are India, China, the United States, Malaysia, and the United Kingdom. Figure 7 shows that the publications between countries mostly come from Asian countries, with India being the central axis of collaboration and disseminating the studies to other latitudes. China is the main collaborator between the United States and the United Kingdom, leaving the latter as the primary node of Europe, Africa, and South America, extending its ties to the South American continent with a country like Colombia; Malaysia is the link country to the African continent.

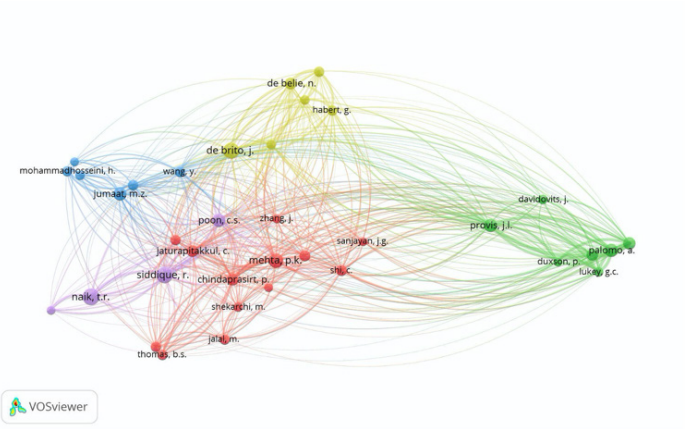
Figure 7. *Co-authorship (countries) on publications*



Co-authorship analysis

There is a collaborative dynamic between co-authors who develop investigative processes at a global level, generating as a result of the search equation significant support networks for the advancement of new production technologies, expansion of knowledge, and innovative alternatives for the protection of the environment and sustainable development. It is evident in Figure 8 that collaborative networks are concentrated in five main aspects, which in turn interact widely with each other, consolidating large dynamic and diverse sources of information. Those with the most significant collaboration are the researchers from the red side, which generate different links with the other nodes, and the researchers from the yellow nodes that establish extensive collaborative networks. The green nodes are the side with the most significant collaboration between yes, but they do not generate many links with researchers from different latitudes.

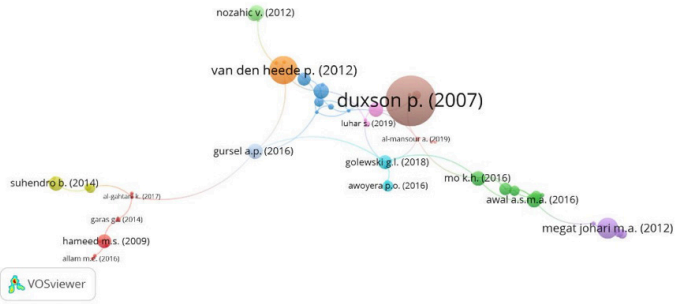
Figure 8. *Co-authoring network*



Citation analysis (documents)

It is of great relevance to know the authors' dynamics, evolution, and relationship over time to identify the years and the author of the most significant scientific interest on the subject in question. Figure 9 identifies the networks between authors and their evolution. For example, the author Van Den Heede has eight networks, which indicates that he is the author who has more relationships with other researchers. It can also be observed that the blue nodes' networks have approximately six links that make the relationship between them notorious. It is also observed that the authors of the red links are American and that although the engineer Peter Duxson has the largest node, it is the one with the least links.

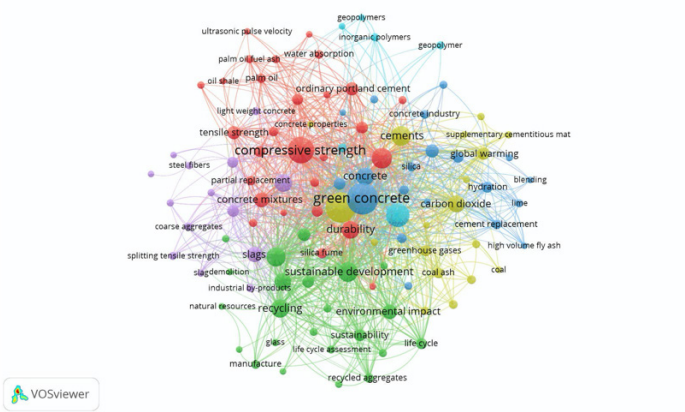
Figure 9. *Document citations analysis*



Keyword Co-occurrence Analysis

It can be seen in Figure 10 that the red slope is based on the mechanical and chemical properties of concrete, the blue links are focused on polymers, and the green slope is the environmental impact that the manufacture of concrete can generate. It should be noted that the word "concretes" has an occurrence of 99 with 848 links, but the essential keyword, "green concrete," has 111 occurrences and 817 links. It is noted that "green concrete" is the word with the highest occurrence, but it has fewer links than "concretes," which indicates that the two words named above are the most used in all the documents found.

Figure 10. *Keyword co-occurrence*



Conclusions

The first publication on the subject was recorded in 1983, and from then until 2006, its annual growth was relatively slow. As of 2007, and henceforth until 2020, research on green concrete had considerable growth, expressed in more excellent scientific production, since 188 articles were published, corresponding to 93.5% of the total scientific production.

The most relevant source is the Journal of Cleaner Production, with 20 published articles corresponding to 9.9% of the publications' total distribution. Second, the Construction and Building Materials source appears with 15 articles. It is notable that 15 journals are European and have 82 published articles that correspond to 40.8% of total publications.

With the most extended validity in time, the author is Li Y since his publication record has been maintained between 2009-2020, highlighting that in 2009 he had 29 citations. In 2010, the total number of citations was 2, respectively.

The authors Mohammad Hosseini H, with five (5) publications and an h-index of four (4) and Allam Me, with four (4) publications and an h-index of three (3), are the most internationally recognized authors and those with the highest scientific production about green concrete.

The keyword "concrete" is most often referred to by authors in their articles on green concretes. The keyword "green concrete" followed by "compressive strength" appears in the next degree of importance. Additionally, the words are divided into three main aspects that stand out for their chemical and mechanical properties, polymers, and environmental impacts.

Developed and developing countries produce the highest amount of CO2 due to their urban growth and polluting materials such as concrete. For this reason, researchers from countries such as India, China, the United States, the United Kingdom, and Malaysia lead the investigations of new technologies and recyclable raw materials such as polymers. They are generating that their investigations are regularly consulted by interested parties and researchers from other latitudes.

References

Al-Mansour, A., Cheuk Lun, C., Luciano Feo, R. P., and Denvid L.. (2019). "Green Concrete: By-Products Utilization and Advanced Approaches." *Sustainability, 11*(19).

Ali, Ahmed A. Mohamme., Roua Suhail Zidan, and Baraa J. M. Al-Eliwi. 2020. "Evaluation of Mechanical Properties of High-Strength Concrete with Sustainable Materials." IOP Conference Series: Materials Science and Engineering 745(1).

Aria, M. and Cuccurullo, C. (2017). Bibliometrix: An R Tool for Comprehensive Scientific Mapping Analysis, *Journal of Informetrics, 11* (4), pp 959-975, Elsevier, DOI: 10.1016 / j.joi.2017.08.007

Azad, A., Saeedian, A., Mousavi, S. F., Karami, H., Farzin, S., & Singh, V. P. (2020). Effect of zeolite and pumice powders on the environmental and physical characteristics of green concrete filters. *Construction and Building Materials, 240*, 117931.

Azarsa, Peiman, and Rishi Gupta. 2020. "Durability and Leach-Ability Evaluation of K-Based Geopolymer Concrete in Real Environmental Conditions." Case Studies in Construction Materials 13:e00366.

Bosro, M. Z. M., Samad, A. A. A., Mohamad, N., Goh, W. I., & Tambichik, M. A. (2020, May). Finite Element Analysis of Green Concrete Hollow Block (GCH block) System. In IOP Conference Series: Earth and Environmental Science (Vol. 498, No. 1, p. 012039). IOP Publishing.

Boyle, F., & Sherman, D. (2006). Scopus™: The product and its development. *The Serials Librarian, 49*(3), 147-153.

Bunnori, N. M., Alani, A. H., Noaman, A. T., Johari, M. M., & Majid, T. A. (2020). Relationships between Compressive Strength and Transport Properties of Ultrahigh-Strength Green Concrete Utilizing Ternary-Blended Binder. Journal of Materials in Civil Engineering, 32(3), 04020011.

Burnham, J. F. (2006). Scopus database: a review. *Biomedical digital libraries, 3*(1), 1-8.

Cornelis, Remigildus, Henricus Priyosulistyo, Iman Satyarno, and Rochmadi. 2019. "Workability and Strength Properties of Class C Fly Ash-Based Geopolymer Mortar." MATEC Web of Conferences 258:01009.

Hamada, Hussein, Bassam Tayeh, Fadzil Yahaya, Khairunisa Muthusamy, and Alyaa Al-Attar. 2020. "Effects of Nano-Palm Oil Fuel Ash and Nano-Eggshell Powder on Concrete." Construction and Building Materials 261:119790.

Haza, Z. F., Shulhan, M. A., & Kadis, K. B. (2020, February). Characteristic of melted slag from wrought iron industry as green concrete material. In IOP *Conference Series: Materials Science and Engineering, 767*(1), p. 012006). IOP Publishing.

Katiyar, Manoj, and Surendra Pal-Singh. 2019. "Concrete with Alternative Aggregates." International Research Journal of Engineering and Technology (IRJET) 6(2):1–12.

Khalil, W. I., and N. F. Al Obeidy. (2020). "Some Properties of Green Concrete with Glass and Plastic Wastes." IOP *Conference Series: Materials Science and Engineering 737*(1).

Mohammadhosseini, H., Alyousef, R., Lim, N. H. A. S., Tahir, M. M., Alabduljabbar, H., Mohamed,

A. M., & Samadi, M. (2020). Waste metalized film food packaging as low cost and ecofriendly fibrous materials in the production of sustainable and green concrete composites. Journal of Cleaner Production, 258, 120726.

Muhamad, K., Zainol, N. Z., Yahya, N., Noor, S. N. A. M., Hashim, N. H., & Shahrazi, D. Z. (2020, April). Influence of rice husk ash (RHA) on performance of green concrete roof tile in application of green building. In IOP Conference Series: Earth and Environmental Science (Vol. 476, No. 1, p. 012038). IOP Publishing.

Nagarkar, Mr. Vardhan. 2017. "Experimental Study on Green Concrete." International Journal for Research in Applied Science and Engineering Technology V(IV):702–5.

Nguyen, H. A., Chang, T. P., Lee, P. H., & Shih, J. Y. (2020). Experimental Investigation of Bond- Slip Performance of Reinforcement in Two Green Concretes. Journal of Materials in Civil Engineering, 32(3), 04020014.

O'Reilly Díaz, V. A., Bancrofft Hernández, R. A., & Ruiz Gutiérrez, L. (2010). Las tecnologías del concreto en su ciclo de vida. Concreto y cemento. Investigación y desarrollo, 1(2), 42-47.

Oyebisi, Solomon, Tobit Igba, Akeem Raheem, and Festus Olutoge. 2020. "Predicting the Splitting Tensile Strength of Concrete Incorporating Anacardium Occidentale Nut Shell Ash Using Reactivity Index Concepts and Mix Design Proportions." Case Studies in Construction Materials 13:e00393.

Palanisamy, Magudeaswaran. (2020). "Reduction in green house gas and agricultural solid waste in green." (June).

Parihar, Raghvendra Singh, and Siddharth Pastariya. (2020). "Experimental Investigation of Green Concrete in Construction Industry by Using Recycled Aggregate (Demolished Waste)." (May).

Rehman, M. U., Rashid, K., Zafar, I., Alqahtani, F. K., & Khan, M. I. (2020). Formulation and characterization of geopolymer and conventional lightweight green concrete by incorporating synthetic lightweight aggregate. Journal of Building Engineering, 101363.

Saadoon, Ahmed Sagban. 2019. "Revision Study of Green Concrete." (October).

Sadowski, Ł., Nikoo, M., Shariq, M., Joker, E., & Czarnecki, S. (2019). The nature-inspired metaheuristic method for predicting the creep strain of green concrete containing ground granulated blast furnace slag. Materials, 12(2), 293.

Sanyal, D., Kodgire, S., Desai, D., Saxena, N., Singh, S., & Dasgupta, S. (2020). Commitment for a Cleaner India: Utilization of CO 2 and Sewage Wastewater by Green Algae Scenedesmus sp. Under Laboratory Conditions. In Renewable Energy and Climate Change (pp. 277- 286). Springer, Singapore.

Shanmugavel, Durgadevagi, Thirumalini Selvaraj, Ravi Ramadoss, and Simona Raneri. 2020. "Interaction of a Viscous Biopolymer from Cactus Extract with Cement Paste to Produce Sustainable Concrete." Construction and Building Materials 257:119585.

Shukla, A., Gupta, N., Goel, R., & Kumar, S. (2020, April). Study on the Behaviour of Green Concrete by the use of Industrial waste Material: A Review. In IOP Conference Series: Materials Science and Engineering (Vol. 804, No. 1, p. 012036). IOP Publishing.

Suhendro, Bambang. 2014. "Toward Green Concrete for Better Sustainable Environment." Procedia Engineering 95(Scescm):305–20.

Tang, Waiching. 2020. "Special Issue on Green Concrete for a Better Sustainable Environment." Applied Sciences (Switzerland) 10(7):3–5.

Thiruvenkitam, M., Pandian, S., Santra, M., & Subramanian, D. (2020). Use of waste foundry sand as a partial replacement to produce green concrete: Mechanical properties, durability attributes and its economical assessment. *Environmental Technology & Innovation, 19,* 101022.

Turuallo, Gidion, and Harun Mallisa. 2019. "Sustainable Cementitious Materials: The Effect of Fly Ash Percentage as a Part Replacement of Portland Cement Composite (PCC) and Curing Temperature on the Early Age Strength of Fly Ash Concrete." MATEC Web of Conferences 258:01001.

Van Eck, N. J., & Waltman, L. (2010). Software survey: VOSviewer, a computer program for bibliometric mapping. *Scientometrics, 84*(2), 523-538

Zhao, Jian, Peiwei Gao, and Zhengxun Yang. 2020. "Fabrication of Green Concrete by Using Recycled Construction Waste." IOP Conference Series: Materials Science and Engineering 774(1).